Cognitive performance, age, and health-related factors

Chapter 8

Cognitive performance, age, and health-related factors

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INTRODUCTION

It is well established that the average individual experiences a decline in virtually all cognitive functions as he or she grows older (Birren & Schaie, 1990). Although this may be the case, there is also considerable evidence that not all functions decline at the same rate (Rabbitt, 1990). Verbal abilities, for instance, may remain largely intact until very advanced age, whereas functions involving speeded mental processing may be already appreciably affected in the fourth decade (Houx, Vreeling & Jolles, 1991). Furthermore, it is by no means clear whether all normal, non-diseased, and non-demented individuals suffer age-related decline in cognitive abilities to the same extent. In fact, in recent years evidence has been presented to show that there may be substantial individual differences. It has been argued that, for a given biological or cognitive function, normal individuals may show *successful* aging, involving little or no decline, as well as *usual* aging with some or considerable decline (Rowe & Kahn, 1987; Stones, Kozma, & Hannah, 1990). In earlier work (The Maastricht Memory Study; Houx, 1991; Houx & Jolles, 1994), we demonstrated that Biological Life Events (BLE) might explain some of the considerable differences that can be found in cognitive test performance, especially in elderly individuals. BLE were defined as health-related factors, experienced at any time in life, that are known to affect brain functioning in otherwise normal people. Examples are repeated mild head injuries, surgical interventions under general anaesthesia, or prolonged (but not actual) use of psychotropic medication. In medical practice, these factors are typically regarded as having no long-term effect on memory and other cognitive functions. In a large sample (N=262) of healthy subjects of various age, we found however that BLE accounted for a major part of the individual variation in test performance, comparable to the effect of age. Moreover, the difference due to BLE was greater in the older subjects, which suggests that BLE may worsen age-related cognitive decline (see Chapter 2, for a more extensive discus-

sion). BLE can be thought of as lowering the threshold for the development of small functional deficits by reducing *brain reserve capacity*, a concept put forward by Satz (1993).
This study addresses the question whether the same clear-cut age by BLE interactions can be identified in the subjects who volunteered for the MAAS–A_1 panel study. To this end, the data on cognitive test performance were treated as a replication study of the earlier MMS. Specifically, the hypothesis was tested that, apart from the expected age-related decline, considerable effects of BLE can be identified in normal subjects and especially in the elderly. For the purpose of this chapter, a few cognitive functions studied in A_1 were selected, so that test performances observed in MMS and A_1 could be compared. At present, test data from $A_{2\text{-}4}$ are not available. The sample of subjects is described in Chapter 3.

METHOD

Subjects. For the purpose of comparability with the MMS, BLE were scored as either absent (0) or present (1). This was done according to the MMS criteria (Houx & Jolles, 1991) which deviate to some extent from the MAAS criteria, in which, e.g., BLE are scored at three levels (Section 3.4.2). The recruitment of the subjects for A_1 differed from that for the MMS in that they were not invited to reply to an advertisement but were approached directly via the general practitioner. Furthermore, there was a finer stratification for age. Ages in MMS were grouped around whole tens of years (20±3 years, ..., 80±3 years), whereas in $A_{1\text{-}4}$ ages are grouped around multiples of five (25±1 years, ..., 80±1 years). For the purpose of comparison with the MMS, six successive pairs of age groups were collapsed into one: 25±1, 30±1, ..., 75±1, 80±1 years.

Cognitive tests. Three tests are discussed here, namely, verbal learning, a test for reaction time and motor response preparation, and an often used test for selective attention. These tests are used throughout $A_{1\text{-}4}$. For more extensive descriptions of these tests, see Section 4.2.
(1) *Verbal Learning Test.* Fifteen words are presented in succession. The subject immediately reproduces every word he or she can recall. This is repeated five times with the same set of words. After some twenty minutes recall is tested once again, followed by testing of item recognition.
(2) *Motor Choice Response Task.* The subject is requested to hold down, with the index finger, a red home button (see Figure 8.1, button 0). One of the buttons (2–3–4) can light up. There are three conditions with different instructions: *simple*, to press with the same finger button 3 when it lights up; *choice*: to press the button that lights up (2–3–4); *incompatible*: to press the button clockwise adjacent to the lit button (2–3–4). In all conditions, button 0 is to be held down immediately after the target

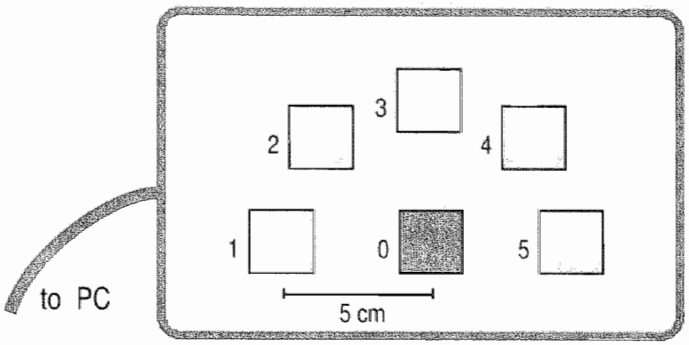

Fig. 8.1.
Lay out of Motor Choice Reaction Time (MCRT) button box.

Table 8.1.
Effects of age, sex, BLE and the age by BLE interaction.

	Age $F(5,n\text{-}26)$	Sex $F(1,n\text{-}26)$	BLE $F(1,n\text{-}26)$	Age x BLE $F(5,n\text{-}26)$
Word Learning Task				
Total 5 trials	27.7***	43.3***	3.9*	1.0
Max. performance of 5 trials	28.9***	20.8***	2.8	1.7
Total: recall	22.0***	35.6***	2.6	1.1
Stroop Color-Word Test				
Task I	9.8***	<1	2.8	<1
Task II	15.4***	2.3	1.4	<1
Task III	33.6***	1.0	1.9	<1
Reaction Time				
Simple, initiation	13.6***	7.7**	3.3	<1
Simple, movement	31.8***	43.4***	4.0*	1.4
Incompatible, initiation	31.4***	5.4*	2.7	<1
Incompatible, movement	49.0***	63.9***	4.7*	1.2

Note. *F*-values. *N* of subjects: 469. Six age groups: 25/30, 35/40, 45/50, 55/60, 65/70, and 75/80 years. BLE scored as absent/present. *$p \leq .05$, **$p \leq .01$, ***$p \leq .001$.

button is pressed until the next button lights up. All conditions involve motor initiation (reaction time), movement, press-down, and reset time. (3) *Stroop Color-Word Test*. The test involves three parts: I. reading colour names aloud, II. naming coloured patches, III. naming ink colour with interference of incongruous colour names (e.g., 'GREEN' printed in red ink; the required response is 'RED').

Table 8.2.
Test performance in MAAS-A_1 (N=469).

			Age class 25/30	35/40	45/50	55/60	65/70	75/80
Word learning test								
Max.recall	–	*M*	12.7	12.7	11.5	11.6	10.6	9.9
		SD	(1.9)	(2.0)	(2.0)	(2.0)	(2.3)	(2.2)
	+	*M*	12.8	12.1	11.7	11.7	10.4	9.0
		SD	(1.8)	(1.8)	(1.8)	(1.9)	(2.3)	(2.3)
Total recall	–	*M*	49.0	49.5	43.7	43.8	39.6	35.5
		SD	(8.7)	(7.8)	(7.7)	(9.1)	(8.8)	(9.0)
	+	*M*	48.7	46.7	44.8	44.4	37.6	31.8
		SD	(8.5)	(9.1)	(7.9)	(8.2)	(9.6)	(8.5)
Delayed rec.	–	*M*	10.8	11.1	9.2	9.1	8.4	6.5
		SD	(2.5)	(2.5)	(2.7)	(2.5)	(2.8)	(3.0)
	+	*M*	10.8	10.1	9.5	9.3	7.7	6.4
		SD	(2.6)	(2.8)	(2.8)	(2.6)	(2.9)	(2.5)
Stroop Test								
Part I	–	*M*	41.4	44.2	46.3	47.3	49.1	51.3
		SD	(6.6)	(6.4)	(7.6)	(7.2)	(8.0)	(6.2)
	+	*M*	43.4	44.2	46.8	48.2	51.4	52.2
		SD	(6.7)	(9.4)	(8.8)	(7.4)	(8.6)	(7.7)
Part II	–	*M*	53.4	54.8	56.1	63.2	62.8	67.5
		SD	(8.2)	(8.3)	(8.7)	(11.0)	(10.0)	(9.9)
	+	*M*	53.2	55.9	59.1	60.4	64.2	69.1
		SD	(7.7)	(10.6)	(10.8)	(8.6)	(11.1)	(10.7)
Part III	–	*M*	84.4	83.4	91.7	103.9	109.5	128.3
		SD	(16.3)	(14.9)	(21.4)	(21.2)	(22.1)	(27.6)
	+	*M*	79.7	87.4	92.4	103.1	115.8	133.1
		SD	(15.1)	(22.3)	(19.5)	(26.2)	(27.8)	(28.4)
Reaction Time								
Simple	–	*M*	316.0	322.5	328.1	350.7	374.4	360.4
		SD	(40.7)	(46.3)	(54.9)	(45.7)	(68.9)	(53.4)
	+	*M*	326.9	323.7	333.9	357.3	387.4	390.9
		SD	(34.9)	(35.2)	(30.8)	(69.2)	(87.3)	(68.0)
Complex	–	*M*	459.4	470.3	469.3	519.5	542.0	579.5
		SD	(48.2)	(52.3)	(56.4)	(83.9)	(69.0)	(87.6)
	+	*M*	458.2	483.8	473.5	526.5	569.2	601.1
		SD	(41.9)	(63.2)	(59.0)	(80.5)	(88.9)	(103.0)

Note. Verbal learning performance: maximum recall, total recall (in all five trials), and delayed recall. Stroop test: the times needed to complete each test part. Reaction times: the time in milliseconds to respond in a very simple and a rather more complex situation. Without BLE (–), or with (+).

Table 8.2. (continued). Test performance in Maastricht Memory Study (MMS '87– '90) (*N*=247).

			Age class					
			30	40	50	60	70	80
Word learning test								
Max.recall	–	*M*	13.7	13.4	13.3	13.2	13.6	13.8
		SD	(1.4)	(0.9)	(1.2)	(0.9)	(0.9)	(0.9)
	+	*M*	12.4	11.9	12.1	11.0	10.0	9.0
		SD	(2.2)	(2.4)	(1.3)	(1.7)	(1.5)	(1.7)
Total recall	–	*M*	55.2	51.4	52.5	49.6	50.6	50.5
		SD	(6.6)	(5.2)	(5.4)	(5.4)	(5.5)	(6.3)
	+	*M*	51.1	47.3	49.4	44.1	39.6	33.9
		SD	(9.2)	(9.8)	(6.1)	(6.9)	(6.0)	(7.0)
Delayed rec.	–	*M*	12.1	11.9	11.5	11.3	11.7	11.5
		SD	(1.5)	(1.3)	(1.4)	(1.4)	(1.8)	(2.1)
	+	*M*	10.9	9.8	9.9	9.7	7.1	5.8
		SD	(2.0)	(2.2)	(2.1)	(1.8)	(2.6)	(2.7)
Stroop Test								
Part I	–	*M*	39.6	39.9	37	41.5	41.3	44.1
		SD	(6.1)	(4.9)	(4.9)	(4.4)	(4.2)	(4.6)
	+	*M*	41.1	40.1	41.2	46.3	43.1	50.9
		SD	(6.1)	(4.2)	(4.1)	(8.5)	(4.9)	(6.8)
Part II	–	*M*	54.0	52.7	50.1	56.1	56.4	61.6
		SD	(8.1)	(9.6)	(9.3)	(6.9)	(5.9)	(8.5)
	+	*M*	52.8	51.7	57.4	58.6	63.2	73.3
		SD	(10.1)	(6.6)	(8.9)	(6.7)	(11.4)	(19.9)
Part III	–	*M*	80.8	86.4	81.3	93.6	99.5	105.5
		SD	(14.5)	(21.4)	(12.0)	(16.9)	(21.2)	(14.9)
	+	*M*	91.4	92.8	92.3	102.2	138.1	181.1
		SD	(23.1)	(16.2)	(10.0)	(19.0)	(36.2)	(45.6)
Reaction Time								
Simple	–	*M*	289.1	294.6	283.6	307.9	326.0	343.3
		SD	(26.8)	(35.3)	(20.4)	(57.7)	(37.9)	(48.7)
	+	*M*	288.1	294.1	307.1	330.0	360.7	451.6
		SD	(45.7)	(31.7)	(32.6)	(38.1)	(108.7)	(164.7)
Complex	–	*M*	418.8	437.9	426.4	483.6	512.2	538.4
		SD	(48.7)	(67.7)	(48.1)	(102.1)	(80.4)	(81.0)
	+	*M*	435.8	434.3	464.2	543.4	803.8	1023.8
		SD	(68.7)	(35.0)	(66.0)	(71.3)	(332.6)	(356.3)

Statistics. Main and interaction effects of the independent variables age, sex, and BLE-status (0 or 1) were analysed with analysis of covariance (ANCOVA), using IQ as covariate measure.

RESULTS

Table 8.1 summarizes the results of a number of ANCOVA's. Age consistently affected performance in all dependent variables. The same was true for sex in the verbal learning task (VLT) and the motor choice response task (MCRT). Female subjects had better scores for memory performance as measured with the verbal learning test and male subjects had better scores for the psychomotor variables from the MCRT. For some of the variables, the existence of BLE had a significant effect. None of variables showed an age x BLE interaction.

Some of the set of test scores obtained in A_1 and in the MMS are given in Table 8.2. In general, the A_1 data differ in several respects from the data obtained in the MMS. Performance on the verbal learning task was much poorer in A_1 than in the MMS. In fact, it closely resembled that of the BLE-affected subjects in the MMS. Also, the age-related decline in test performance was more pronounced, which again was similar to the decrement found in BLE subjects. In particular, this was true for the maximum recall of all five learning trials: in BLE-free subjects, there was no age-related decline in the MMS at all, whereas the results of A_1 suggested a decrement that was only marginally less in BLE-free subjects than in their BLE-affected age-mates. Furthermore, none of the A_1 subjects aged 80 attained a level of performance that was comparable to the average performance of the BLE-free MMS subjects of the same age. The performance on the Stroop test of the A_1 subjects was more similar to that of the MMS subjects. Generally, for all test parts the subjects needed a little more time than the subjects without BLE in the MMS (in the order of 10%). Again, the effects of BLE were much smaller. The response times of the BLE-free and affected subjects tended to be in between those of both groups in the MMS. The very striking fanning out (increasing differences in performance on subtasks with age) that was seen in the BLE-affected subjects in the MMS was not replicated. This description also applies with respect to the choice response performance.

DISCUSSION

Significant main effects of age and BLE were found by means of ANOVA's. When BLE effects were not significant, the group differences were almost invariably in the predicted direction. This replicates the earlier findings of Houx and Jolles (1993; 1994) and Houx et al. (1993). However, these BLE effects were smaller than those found in the earlier study, and less systematic. Moreover, the difference in performance

between BLE-free and BLE-affected subjects did not increase with age, as substantiated by the virtual absence of significant age x BLE interaction effects. This was true for nearly all of the tests presented here. It is possible that with other tests interactions will be found, but the results of these tests have not been analysed yet. Also, the role of other individual variables has not yet been investigated. These findings are therefore very preliminary. However, the tests discussed here were among those revealing the most striking age x BLE interactions in the earlier study. Some explanations for this discrepancy between the results of the A_1 panel study and the MMS will be analysed:

(1) The procedure of subject recruitment was different in the two studies: in the MMS, subjects were recruited by an advertisement, in the present one, a database of family practice patients was used. Possibly, the latter subjects were less motivated to perform well. Another possibility is that the former subjects were more intelligent.

(2) Data on BLE were gathered differently: in the earlier study, an experienced neurologist carried out a semi-structured interview with the subjects whereas in the present study the data were collected by means of a postal survey, which was checked during a home visit by a research nurse.

(3) The overall test performance of the subjects tended to be lower in the present study. This is in accordance with the notion that the composition of the present sample is different from the earlier sample, at least with respect to motivation and/or general ability.

With respect to the first explanations (other sample composition), it is conceivable that the subjects in the MMS, especially the elderly subjects, constituted an elite of highly intelligent, highly motivated volunteers. After all, they responded to an advertisement in a local newspaper. This implies more spontaneous action, perhaps suggesting a more enterprising personality. Conversely, the subjects for the A_1 panels were randomly approached and sometimes even persuaded by their own family doctors. One might argue therefore that the A_1 subjects were less willing to volunteer, less interested generally, and therefore less motivated to perform well. If this is true, then there will be similar performance differences in other studies with similar recruitment procedures. An extra argument for this explanation is the good compliance in the 5-years' follow-up of subjects of the MMS –which is currently in progress– and the consistently better performance than seen in A_1, especially on the verbal learning test, even after 5 years. These findings will be published when data collection for the follow-up study has been completed.

As for the second explanation (the procedure of data collection regarding BLE), it is likely that the A_1 data contain a good deal more noise. Assuming that an experienced neurologist is the gold standard in history taking, we would predict that the subgroup thought to be affected by BLE will contain a large proportion of false positives, subjects who, for example, overestimate the impact on the brain of a bump on the head.

Also, the subjects deemed free of any factors that affect the brain may well have forgotten an event, or be unwilling to give information on something as sensitive as alcohol consumption or some types of operations. Indeed, the BLE status of some subjects was changed based on additional information from the home interview (Section 3.4.2). It may be expected that an experienced neurologist is able to explore BLE-status in even more detail. Therefore, in order to test this hypothesis a sample of the subjects could be reexamined by the neurologist.
The overall poorer test performance observed in A_1 may be –at least in part– due to lower motivation of the subjects to perform well. Another possible explanation might be found in the data collectors themselves. In the MMS, most of the cognitive testing was done by the first author, who was also the researcher with scientific interest in the project. Perhaps this motivated him to elicit the very best performance from the subjects. At the same time test assistants, even when well trained, cannot be expected to always share the scientific interest. Tester bias of this kind could be studied by analysing test performance in relation to the tester.

As stated earlier, these results are preliminary. The analyses presented here are based on the first of four procedurally identical projects. From these projects, data obtained from the test discussed here, and from many other data sources, can be pooled. Many of the interaction effects with nonsignificant *F*–values had *alpha* levels only slightly more than 5 percent. Thus pooling of the data may enhance the power to detect effects. Although this will probably be the case, it cannot conceal the fact that neither the BLE main effects, nor the interaction effects with other variables, were nearly as robust as those found in the MMS.
These findings cast some doubt on the generalizability of the earlier findings with regard to BLE. It appears that the robust effects that factors that affect brain health have on cognition in one group, cannot be assumed to have the same marked effects in another group. For some of the tests, the performance in A_1 resembled that of the BLE-affected subjects in the MMS. One could speculate that the volunteers in the latter study 'had more to lose' in terms of 'brain reserve capacity' (Satz, 1993). If they are indeed an elite, with correspondingly higher levels of initial cognitive functioning and cognitive resources (Salthouse, 1988), factors limiting this reserve capacity may well have a greater effect on these more gifted individuals. This hypothesis can be tested by studying BLE-unaffected subjects who had participated in the earlier study, but who have since sustained a BLE. It would be expected that these subjects, and especially the elderly volunteers, would show a more severe drop in cognitive performance.

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